Reminders about Kirchhoff's Laws

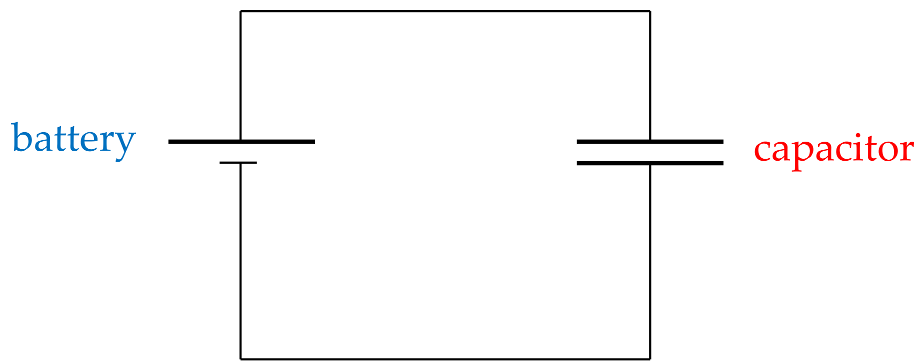
- Junction rule: current in = current out
- Loop rule: sum of potential differences around a closed loop = 0
- To solve for multiple unknowns, need as many equations as you have unknowns, then:
  - Use substitution method (if simple), OR
  - Rearrange equations into determinant form (meaning, all I terms on left side, constants (voltages) on right side), then use matrices
    - Matrix solving can be done:
      - By hand
      - With TI calculator using rref([A]) where A is a matrix with V terms in last column
      - With TI calculator using matrix [A] = all I coefficients and matrix [B] = constants, then doing $[A]^{-1}[B]$

Complex Circuits lab

- Make sure you get ALL your data before leaving lab, and check with me before you do! Remember to present your data in your lab report before starting any calculations - make it easy for your reader (me) to see what you measured.
- Read the instructions - they walk you through the set up and measuring.
- Don't leave the analysis until the night before it's due. Setting up your loops and identifying your currents will take some thought - leave yourself time to ask questions if you need to. Writing up this lab will also help you study for the test…
  - *I cannot stress enough - getting as much of this done in the next day or two is in your best interest, so you have time to come ask me questions!*
- Write up is due

Capacitors

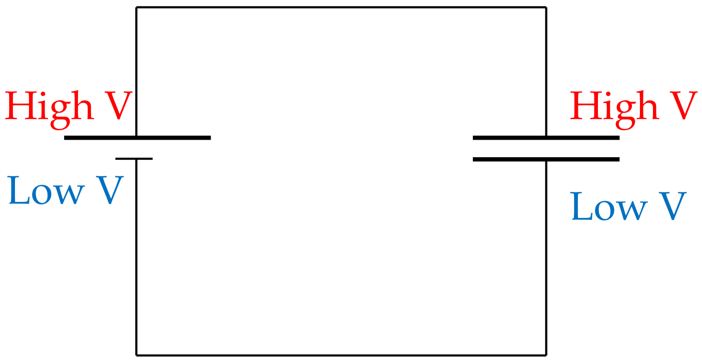
- A **capacitor** is another device that can be used in circuits, and as its name implies, it has a certain capacity to store…something
- In a circuit, we indicate a capacitor with two equal-length parallel lines, like this:



- When have you seen something like this before? What's going on between the plates and why?

Capacitors

- A simple capacitor consists of two parallel plates of area *A*, separated by a distance *d* filled with air or another material (more on that later).
- An "empty" capacitor has net neutral charge and equal potential plates (0 V each).
- When a capacitor is hooked up to a battery, what happens?



Initially, the uncharged capacitor plates have zero potential, which means there is a potential difference between the + terminal of the battery and the "top plate" of the capacitor. This induces charge to move until the plates of the top capacitor's plate voltage is equal to the battery voltage.

As the top plate charges positive (+Q), it electrostatically repulses like charge (+Q) off the bottom plate leaving it with an equal amount of opposite charge (-Q).

So what is the *net charge* on the capacitor, and what is being storing?

The cap is overall electrically neutral, and it stores energy!

Capacitance

- The **capacitance (C)** of a capacitor can be found by:

$$C = \frac{Q}{\Delta V}$$

Q: Charge on one plate in Coulombs; always +

ΔV: Potential difference between the plates (also +)

Units for capacitance: C/V = **Farads**

- What can we use a charged capacitor for?

Camera flash attachment - capacitor discharges quickly to release a burst of energy (light)

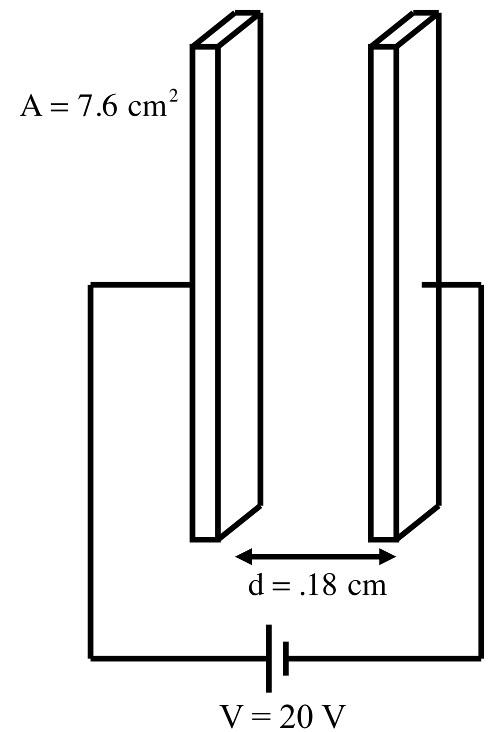
AED - releases a burst of energy to restart a person's heart if needed

Keyboards - when you press a key, you change the spacing of the capacitor plates, which is registered by the circuit

And lots of others!

Anatomy of a capacitor

- A parallel-plate capacitor is the most common geometry, and looks like this →



- What factors could affect the capacitance, and how?
- For a parallel plate capacitor filled with air between the plates, $C = \epsilon_0 \frac{A}{d}$

  where ϵ_0 is a constant called the permittivity of free space ($8.85 \times 10^{-12}\ C^2/Nm^2$)

- What's the capacitance of this capacitor?

  3.74×10^{-12} F or 3.74 pF

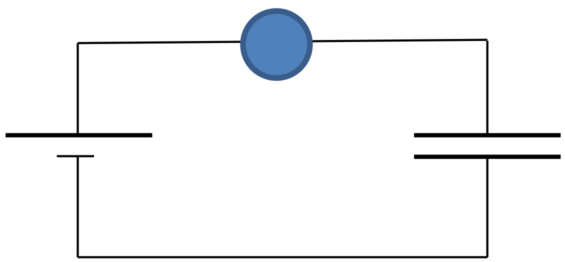
- How much charge is on either plate?

  7.48×10^{-11} C or 74.8 pC

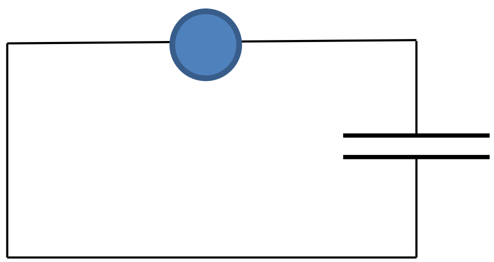
Charging and discharging a capacitor

- What would you observe in a circuit with a DC power source, a lightbulb, and a capacitor all wired in series, when the capacitor was charging?

When the circuit connects, current would flow in the conventional direction (clockwise, here), lighting the bulb and causing the capacitor plates to charge. Once the capacitor was "full" the current would stop - so, essentially, the light will "flash" during charging.



- What would you have to change to allow the capacitor to discharge? What would you observe?



To discharge the capacitor, we can remove the battery. Then, when the "full" capacitor is connected, IT becomes the voltage source, producing a counterclockwise current here until the potential difference between the plates returns to zero. The lightbulb will flash again.

In either case, is the current constant the entire time?